The Coexistence of Wadsleyite and Ringwoodite in L/LL Chondrite SAH 293: Constraints on Shock Pressure Conditions and Olivine Transformation. C. Fudge, J. Hu and T.G. Sharp [1]School of Earth And Space Exploration, Arizona State University, Tempe, AZ 85278, U.S.A. cfudge@asu.edu

Introduction:

The presence of high pressure minerals in highly shocked chondrites provides information on the pressure and duration of shock resulting from impact processes on parent bodies in the main asteroid belt. Ringwoodite, the spinel structured polymorph of olivine, is the most common high-pressure polymorph in ordinary chondrites. Ringwoodite forms by either the solid-state transformation of olivine fragments within shock veins, or by crystallization from the shock melt.

Wadsleyite, the other high-pressure polymorph of olivine, is much less common in meteorites and has only been found in the Peace River L6 chondrite [1]. In this study, we observed pervasive wadsleyite in ordinary chondrite SAH 293. The purpose of this study is to characterize the high pressure phases to estimate the shock conditions and understand why wadsleyite, as well as ringwoodite occur in this sample.

Methods:

Polarized light microscopy (PLM) and Raman spectroscopy were used to study deformation features and to define the mineralogy of the melt veins and pockets. Scanning electron microscopy was then utilized in order to characterize melt-vein texture variation and transformation textures in wadsleyite and ringwoodite. The chemistry of SAH 293 was characterized using Electron Microprobe Analysis (EPMA).

Results:

SAH 293 is a highly shocked ordinary chondrite with numerous opaque melt veins and pockets. The host rock composition consists of plagioclase, olivine and pyroxene with webs of thin to large melt veins and melt pockets which contain transformed olivine as well as undeformed to partially transformed pyroxene fragments. EPMA analyses of the olivine crystals give an average composition of $Fa_{25\text{-}26}$, indicating that this sample is either an L or LL chondrite. Ringwoodite and wadsleyite coexist together within and adjacent to shock melt veins (*Figure 1*).

Solid-State Transformation. All of the olivine fragments in the shock induced melt veins show partial or complete solid-state transformation into high-pressure polymorphs. Both ringwoodite and wadsleyite were observed using polarized light microscopy and verified with Raman spectroscopy (*Figure 2*). Wadsleyite is the dominating olivine phase occurring in the melt veins, with equigranular polycrystalline aggregates that vary from colorless to pale green in plane-polarized light. The ringwoodite occurs along and within melt veins and ranges from colorless to deep blue.

Wadsleyite and ringwoodite are constrained within and in contact with melt veins, whereas maskelynite is less localized, but still occurs predominantly along melt veins and pockets. The presence of ringwoodite in the sample are consistent with shock stage S6 [2], however the presence of plagioclase away from the shock vein indicates a shock stage ~S5. The localization of S6 features to shock melt illustrates the importance of high temperatures in shock-induced phase transitions.

Contrast variations in BES images (*Figure 3a & 3b*) show internal textures consistent with partial transformation of olivine. Slight variations in contrast suggest minor variations in Fe content. However, these variations do not correlate with color variations in wadsleyite or ringwoodite.

Crystallization assemblage. The texture of the melt vein matrix varies spatially along melt vein boundaries and within the interior of the melt veins. Based on textures and experience with other highly shocked chondrites, we infer that the crystallization assemblage is primarily majoritic garnet and magnesiowüstite. Along melt vein boundaries and within small melt veins the texture of majorite and magnesiowüstite are angular and anhedral with rounded sulfide droplets; internally the texture consists of subhedral to euhedral majorite and interstitial magnesiowüstite with less rounded sulfides (*Figure 3c*).

Discussion:

Shock conditions and the coexistence of ringwoodite and wadsleyite. Although the crystallization assemblage of majoritic garnet and magnesiowüstite suggests a crystallization pressure of about 20-23 GPa, the presence of both ringwoodite and wadsleyite suggests a somewhat lower pressure. Although wadsleyite is the stable phase for forsterite-rich compositions, we see no compositional difference between ringwoodite and wadsleyite. Ringwoodite is the higher pressure polymorph of olivine, while wadsleyite is stable at higher temperature. The formation of wadsleyite and ringwoodite likely reflects temperature heterogeneities during shock. At a pressure of ~ 15 to 18 GPa, close to the metastable olivine-ringwoodite boundary, both ringwoodite and wadsleyite are stable relative to olivine. Wadsleyite likely formed stably at high temperature whereas ringwoodite formed metastably, relative to wadsleyite, at lower temperatures. The ubiquity of ringwoodite and the relative scarcity of wadsleyite in S6 L6 chondrites can be explained by shock pressure in S6 samples generally being well above the metastable olivine-ringwoodite equilibrium boundary. In this case, olivine transforms directly to ringwoodite over the full range of transformation temperatures.

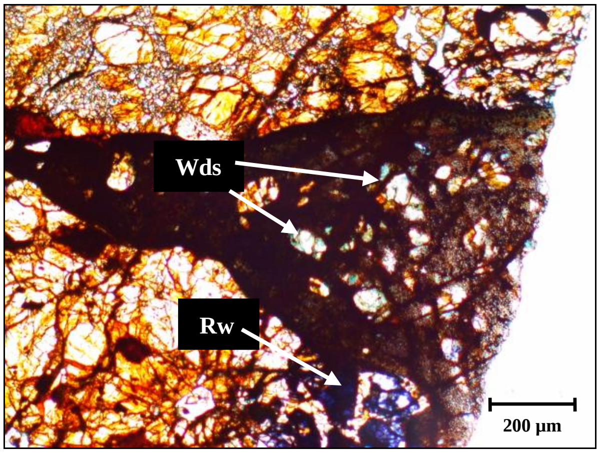

Figure 1: Plane polarized light image of shock melt pocket with wadsleyite and ringwoodite in SAH 293

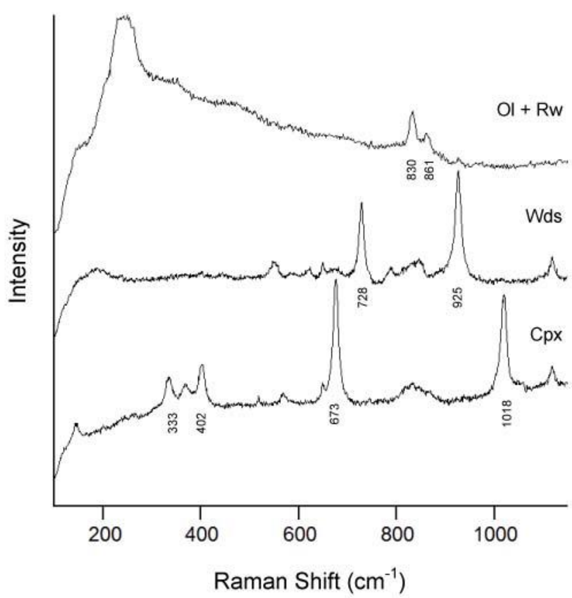

Figure 2: Raman spectra for clinopyroxene, wadsleyite and partially transformed olivine with ringwoodite fluorescence in SAH 293

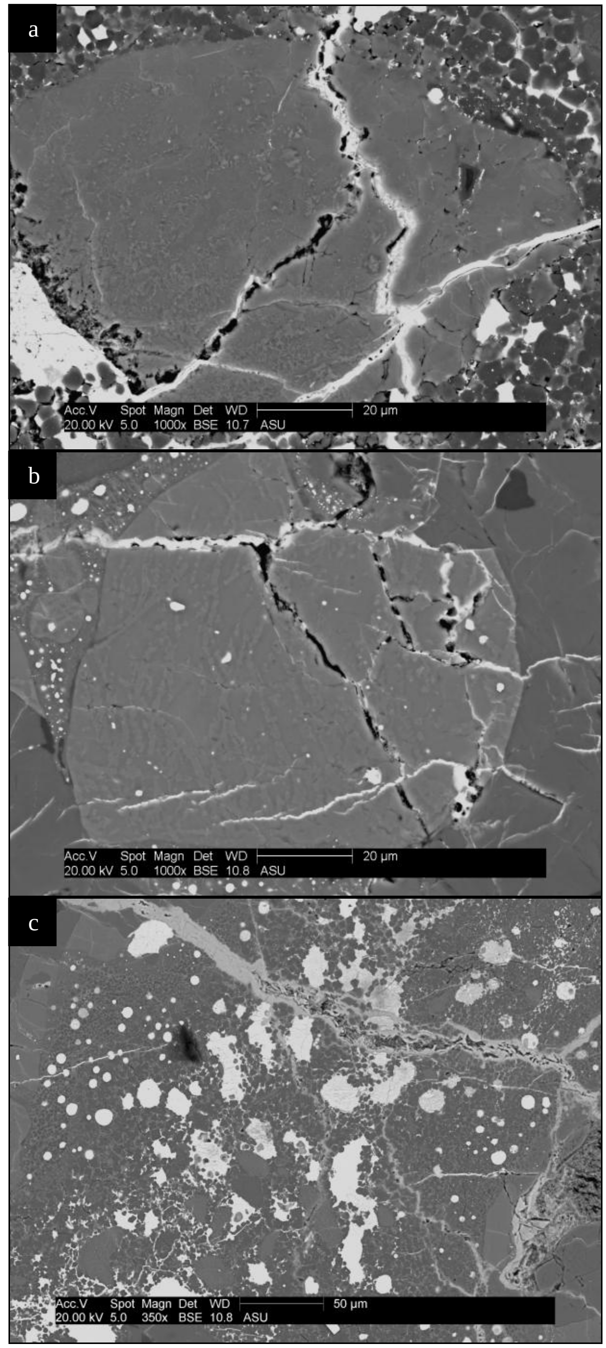

Figure 3a: SEM image showing partial transformation texture in wadsleyite **3b**: Partial transformation texture in ringwoodite **3c**: Shock melt vein texture in SAH293

References: [1] Price G.D. and Smith D.G.W. et al. (1983) *Can. Mineral, 21, 29-35.* [2] Stöffler D. et al. (1991) *Geochim. Cosmochim. Acta*, 55, 3845-3867.